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A Research Study on Leg Dominance and Leg Stability in Dancers

Haley Leoffler

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A Senior Thesis Project

by

Haley Loeffler
Loyola Marymount University, 2018

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Part 1: Formal Journal Article:

Lateral Bias and Stability Differences in Dancers Compared to the General Population

Lateral Bias and Stability Differences in Dancers Compared to the General Population

Haley Loeffler, Loyola Marymount University '18
Christina Reburn, Loyola Marymount University '19

Objective: to see if there is a relationship between leg stability and leg dominance in dancers and non-dancers. We hypothesize that the dancer group will have a smaller difference in stability, or lateral bias, between their legs than non-dancers.

Methods: 35 subjects were recruited (dancers = 17, non-dancers = 18) to be in the study. Each group was tested during a 20-minute testing session on the NeuroCom Balance Master using the unilateral stance test and weight bearing squat test. Leg dominance was determined during a pre-assessment.

Results: The majority of dancers and non-dancers were all right leg dominant. During the unilateral stance, the sway velocity measured was less on the majority of the participants' left legs, meaning their left legs were more stable with eyes open. (p-value 0.4) With eyes closed, the right leg was more stable. (p-value 0.9) During the weight bearing squat test, the non-dancers had a more prominent trend upwards than that of the dancers from 0°, 30°, 60°, and 90° degrees of knee flexion.

Conclusions: Dancers favor their dominant leg almost as much as their non-dominant leg, showing that dancers do not strictly correlate their dominance to stability. More statistical analysis is needed to validate these conclusions further.

Key words
Lateral bias, stability, NeuroCom, leg dominance, unilateral stance, weight bearing squat, sway velocity

Introduction

The purpose of this research is to determine if there is a relationship between ballet training and stability of the lower extremities in comparison to the general population. Additionally, the relationship between leg stability and leg dominance will be explored/investigated. After listening to communication between dancers, the majority stated that over the years, they have determined one leg to seem more stable as the supporting leg over the other. Some of them also claimed that their supporting leg is more stable in a turn, while the other is more stable in a stationary balance. In

ballet, it is customary to begin each combination with the left leg as the supporting leg, the right as the accessory leg, and the left hand on the barre. It has been questioned that over years of this training, the dancer's body might accommodate to such behavior and may favor one side over another.

A study looked at experienced and novice ballet dancers which showed that with practice, experienced dancers developed a preference of their supporting leg in a turn. (C.-W. Lin *et al,* 2013, p.1786) Another study looked at the structure of ballet classes and noted that the classes are taught with a bias to the right side, and this in turn, showed that dancers become more "right-sided" as well. (Farrar-Baker & Wilmerding, 2006, p.83) It raises the question if this aspect of ballet training causes an imbalance of stability that can be measured. "Improper training, in the form of unequal repetitions on right and left sides, known as lateral bias," is shown to be especially present in the ballet technique, and "may create or reinforce habits that are detrimental to a dancer's body and overall technique." (Farrar-Baker & Wilmerding, 2006, p.81) An imbalance of this nature can cause injuries to dancers over time, so it is important for a dancer to be aware if he or she has a bias so they may work in an efficient manner. Before looking at ballet training specifically, leg dominance must be observed and recorded to see if there is a difference in stability as a normally active person. In order to assess the aforementioned question in future studies, this preliminary observational study on leg dominance and stability must be done.

There are some inconsistencies in the literature about how to specifically define which leg is dominant. It can be "established on the basis of strength, functional use, and personal preference, as well as other parameters." (Hoffman *et al*, 1998, p.319) For this study, we will determine the leg dominance through a series of tests explained in the methods portion of this paper that are primarily based on preference and comfortability. The dominant leg is considered the working, or accessory, leg.

We expect that dancers, regardless of which leg they express as their dominant leg, will have a smaller difference in stability when compared to non-dancers. This could be due to their continued work toward being "equal" on both sides and striving for balanced strength, stability, and flexibility on the dominant and non-dominant sides.

Methods

Participants were recruited by asking for volunteers who were female, between the age of 18-26 years old. The participants were divided into two groups: the dancer group (n=17) and the control group (n=18). Forty-seven participants were recruited through email and face-to-face communication (See Appendix A), but 12 were excluded because they either did not meet the inclusion criteria or met the exclusion criteria. To be in the dancer group, the participant must be a member of the Loyola Marymount University dance program, should be enrolled in at least one ballet class for the semester, and have a minimum of 7 years of dance training. Participants of the control group must be students of Loyola Marymount University, non-specific to any particular academic program, that are recognized as healthy, normally active individuals. The participants of the control group were excluded if they have taken a dance class in theatrical dance technique training (i.e. ballet, modern, jazz, etc.) in the last 10 years. Participants were also excluded from the study if they were a collegiate athlete, had a current injury or injury that is still limiting, had a different anatomical leg length, has a scoliosis, or had a history of concussions.

Each participant was required to attend one, 20-minute testing period. This session consisted of completing the pre-assessment Initial Research Participation Questionnaire with the examiner. The examiner then tested for leg dominance by asking the participant to perform a ball-kick test, step-up test, and balance recovery test. The ball-kick test required the participant to simply kick the ball; whichever leg was

used for this action was identified as the dominant leg. The step-up test required participants to step up onto an elevated surface; whichever leg was used to step up was identified as the dominant leg. The balance recovery test required the participant to stand in a neutral posture. The examiner provided a light push to the participant and used a step to recover from falling; whichever leg was used to recover was identified as the dominant leg. If a participant was not clear in which leg was dominant, it was determined that the leg with two out of three occurrences was dominant. (Hoffman *et al*, 1998, p.320)

The participant then began testing on the NeuroCom Balance Master. The two tests performed were Unilateral Stance and Weight-Bearing Squat. The Unilateral Stance asked participants to "stand on either the right or left foot with eyes open and with eyes closed." (Natus Balance & Mobility, 2018) The Weight-Bearing Squat asked participants to maintain equal weight on each leg while standing erect and then squatting in three positions of knee flexion: 0°, 30°, 60°, and 90°. (Natus Balance & Mobility, 2018) These measurements of degree were inconclusive for determining exact angles, but often was assumed. (Trajkov, Nedović, & Šimpraga, 2011, p.43)

Results

After the pre-assessment was completed with the examiner, 35 out of the 47 recruited participants were able to be included in the study. Twelve of the participants initially recruited either did not meet the inclusion criteria or met the exclusion criteria, so they had to be excluded in the study. The dancer group had 17 participants (n=17) and the control group included 18 non-dancers (n=18). The average age of both groups was 20 years old with a standard deviation of 1.37.

Leg Dominance

The control group performed the ball-kick, step-up, and fall recover test and were determined to be primarily right leg dominant (77.8%). **(Table 1.1)** The step-up test, however, showed only an 11.2% difference between the number of right leg dominant to left leg dominant people. In the dancer group, 70.6% were determined to be right leg dominant, similar to the control group. **(Table 1.2)** The dancers were fairly consistent in their performance of leg dominance testing, with an average of 72.6% right-side dominant between the two tests.

In the pre-assessment questionnaire, the dancers were asked to self report which leg they preferred to use as their supporting, or standing, leg in a turn and in a stationary balance. All of the dancers said that during a turn, their left leg felt more stable as the standing leg. **(Table 1.2)** However, in a stationary balance, 7 of them felt more stable on their right leg. The dancers were also asked the level of training in which they perceived themselves. Most of the dancers claimed to be advanced (n=9) or intermediate (n=7), while only one was a beginner.

Unilateral Stance

The unilateral stance tested sway velocity (deg/sec) when standing on the left and the right leg. A percent difference was given between the two measurements and showed whether the participant was more stable on the left or the right based on the direction of the bar graph (See Appendix C). The results are reported in terms of frequency and percentage for eyes open (**Table 2.1**) and

Non-dancers Determined Leg Dominance Testing								
	Ball-Kick		Step Up		Fall Recovery		Preliminary Determined	
	Frequency	Percentage	Frequency	Percentage	Frequency	Percentage	Frequency	Percentage
LEFT	2	11.1	8	44.4	4	22.2	4	22.2
RIGHT	16	88.9	10	55.6	14	77.8	14	77.8

Table 1.1 Non-dancer frequencies and percentages of determined leg dominance from the dominance testing.

DANCER DEMOGRAPHICS								
Dancers Determined Leg Dominance Testing								
	Ball-Kick		Step Up		Fall Recovery		Preliminary Determined	
	Frequency	Percentage	Frequency	Percentage	Frequency	Percentage	Frequency	Percentage
LEFT	4	23.5	4	23.5	6	35.3	5	29.4
RIGHT	13	76.5	13	76.5	11	64.7	12	70.6

Preferred Standing Leg				
	Pref Standing Leg Turn		Pref Standing Leg Stationary	
	Frequency	Percentage	Frequency	Percentage
LEFT	17	100	10	58.8
RIGHT	0	0	7	41.2

Perceived Level of Dance Training		
	Frequency	Percentage
Advanced	9	52.9
Intermediate	7	41.2
Beginner	1	5.88

Table 1.2 Dancer demographics including frequencies and percentages of determined leg dominance, preferred standing leg, and perceived level of dance training.

for eyes closed (**Table 2.2**). The frequencies indicate how many subjects had less sway velocity on which side; for eyes open, 9 subjects had no difference in sway velocity, 20 had less sway velocity on their left leg, and 6 had less sway velocity on their right leg. The percentages reflect those same numbers. The highest percentage was 57.1, seen in the group that swayed less on their left leg. Regarding the eyes closed test, the distribution was more even as 37.1% had less sway velocity on their left leg and 48.6% had less sway velocity on their right leg.

A chi-square test was also applied to the unilateral stance data to test if sway velocity and being a dancer, or non-dancer, were independent; this test was done using the frequencies of people who had no difference in stability, who had expected stability, and who had unexpected stability for both eyes open and eyes closed (**Table 2.3 and 2.4**). The expected category includes data that corresponds to dominance. In other words, the subject had less sway velocity on their non-dominant leg. The unexpected category includes data that opposes predetermined leg dominance; they had more sway velocity on their non-dominant leg. The p-value for this test using the eyes open data was 0.4 and the p-value for eyes closed data was 0.9. With a 95% confidence interval, there is no statistical significance.

Sway Velocity Stability with Eyes Open		
	Frequency	Percentage
Zero	9	25.7
Left	20	57.1
Right	6	17.1

Table 2.1 Number of participants with less sway velocity on their left, right, or neither side during a unilateral stance with eyes open.

Sway Velocity Stability with Eyes Closed		
	Frequency	Percentage
Zero	5	14.3
Left	13	37.1
Right	17	48.6

Table 2.2 Number of participants with less sway velocity on their left, right, or neither side during a unilateral stance with eyes closed.

Stability Based on Determined Leg Dominance with Eyes Open						
	Dancer			Non-Dancer		
	Zero Difference	Expected	Unexpected	Zero Difference	Expected	Unexpected
Frequency	5	7	5	4	11	3
Percent	29.4	41.2	29.4	22.2	61.1	16.7

Table 2.3 Expected, unexpected, or zero difference in stability with respect to leg dominance during a unilateral stance with eyes open.

Stability Based on Determined Leg Dominance with Eyes Closed						
	Dancer			Non-Dancer		
	Zero Difference	Expected	Unexpected	Zero Difference	Expected	Unexpected
Frequency	2	6	9	3	6	9
Percent	11.8	35.3	52.9	16.7	33.3	50.0

Table 2.4 Expected, unexpected, or zero difference in stability with respect to leg dominance during a unilateral stance with eyes closed.

Weight Bearing Squat

The weight bearing squat measures the percentage of body weight borne on each leg at 0°, 30°, 60°, and 90°. The standard deviations of the mean values for the weight distribution ratios are high due to extreme outliers with a few subjects favoring one side strongly (**Table 2.4**). There is a trend towards higher means for the non-dancers as knee flexion increases (**Figure 1**). However, this trend is not statistically significant as the p-values for an independent samples t-test at 0°, 30°, 60°, and 90° are 0.796, 0.936, 0.807, and 0.168, respectively.

Mean and Standard Deviation		
Degrees of Flexion	Dancer	Non-dancer
0	0.235 ± 7.58	0.889 ± 7.23
30	0.706 ± 6.71	0.889 ± 6.73
60	0.941 ± 6.82	1.56 ± 7.84
90	1.41 ± 6.24	4.56 ± 6.89

Table 2.4 Mean and standard deviation of weight distribution difference values for the weight bearing squat at four degrees of knee flexion.

Discussion

Leg Dominance

The majority of the participants were determined to be right leg dominant. There was not a significant difference between the dancer group and control group in terms of dominance. The dancer group self-reported a difference, however, in which leg they preferred. All of the dancers reported that their left leg felt more stable in a turn, which coincides with 76.5% of them being right dominant. Dancers would call this being a proficient "right turner" when doing en dehors pirouettes, for example. There is, however, a discrepancy that 7 of those who reported being more stable on their left leg in a turn reported feeling more stable on their right leg in a stationary balance. Further research is needed to distinguish biomechanical and postural differences between a turn and a stationary balance with respect to the standing leg.

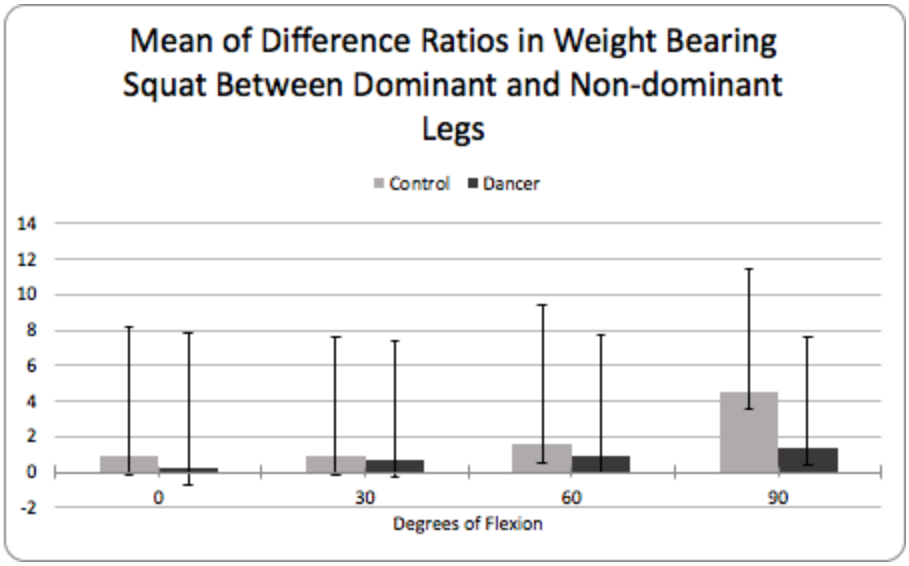

Figure 1 Mean of difference ratios in WBS between dominant and non-dominant legs.

Unilateral Stance

The unilateral stance test shows the magnitude and direction of sway velocity (deg/sec). An amount of sway is normal for the average person, but in this study, we are more concerned with whether the left or right side had more, or less, sway, which is determined by the % difference calculated. During the unilateral stance test with eyes open, the higher percentage of sway velocity on the left leg is unexpected because our subjects collectively had a higher right leg dominance. Again, the dominant leg is referred to as the working, or accessory, leg for this particular study. The left leg as the supporting leg is assumably more stable, and is thus, an unexpected result. The dancer group had a higher number of participants with this unexpected dominance where the non-dancers had more expected dominance (the stable leg is the non-dominant leg). This is, however, reflective on a dancer population because they train to have more equal stability bilaterally. This makes the unexpected and expected values comparable and more similar, further proving this point. However, because of the statistical insignificance, we cannot conclude that dancers are more stable than non-dancers in this manner.

Regarding the chi-square test for independence, the alternative hypothesis is that dancers will have a lower sway velocity as their training emphasises balance, both in the literal sense and bilaterally. Both p-values, for eyes open and eyes closed, greatly exceeded 0.05 and, thus, were not statistically significant. Considering this, the null hypothesis cannot be rejected. It is possible that sway velocity is not affected by being a dancer or a non-dancer. We expected the p-value for eyes closed to be higher because the sense of sight is lost relying completely on the proprioceptors which may throw off stability whether the participant is a dancer or non-dancer.

Weight Bearing Squat

The trend upwards that is seen in non-dancers is not as pronounced in dancers. Dancers had a more even squat at each degree of knee flexion, showing their bilateral balance. For non-dancers, as knee flexion increased, bilateral bias also increased. This trend supports the idea that non-dancers have less bilateral balance or control; however, the p-values do not show statistical significance. At each degree of flexion, the p-value exceeded 0.05. The null hypothesis that the

means between dancers and non-dancers are the same cannot be rejected. It is possible that weight distribution is the same for dancers and non-dancers at the four degrees of knee flexion.

Conclusion

Overall, this study cannot suggest that dancers are more stable than non-dancers. However, we can say that dancers favor their dominant leg almost as much as their non-dominant leg, showing that dancers do not strictly correlate their dominance to stability. More statistical analysis is needed to validate these conclusions further.

Because this study cannot give significance to the data presented, further research is needed to attempt to decrease the standard deviations. This study is a great pilot to more future research in relation to stability and the codification and behaviors of ballet training.

More research should be conducted on the NeuroCom Balance Master as well, as current research shows primarily data for rehabilitation rather than being a leading tool for for quantitative measurements.

References

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Part 2: Appendix A

IRB Proposal

*Submitted December 1, 2017

Received_____

LOYOLA MARYMOUNT UNIVERSITY

Human Subjects Research

APPLICATION TO THE LMU INSTITUTIONAL REVIEW BOARD (IRB)

Principal Investigator (P.I.): **Haley Loeffler**

Title of Project: **Bilateral Stability Differences in Dancers Compared to the General Population in Relation to Ballet Training**

P.I. Type: (check one) ☐ Faculty ☐ Graduate ☒ Undergraduate ☐ Other

Department: **Dance; Health & Human Sciences**

Campus Address: **MSB 3840**

Telephone: **(714) 618-8801** E-mail: **hloeffle@lion.lmu.edu**

Faculty Sponsor (if applicable): Damon Rago, Teresa Heiland, Mavis Rode

Submission: ■ New ☐Renewal ☐ Addendum ☐ Staff ☐ Other Previous IRB#:

For evaluation of your project, indicate involvement of any of the following:

☐ Audio Recording of subjects
☐ Charges incurred by subjects
☐ Deception
☒ Questionnaires
☐ Psychology subject pool
☐ Charges incurred by subjects
☐ Experimental drugs
☐ Establishment of a cell line
☐ Placebos

☒ Non-patient volunteers
☐ Minor subjects (younger than 18)
☐ Mentally disabled subjects
☐ Subjects to be paid
☐ Fetal tissue
☐ Subjects studied off campus
☐ Experimental devices
☐ Surgical pathology tissue
☐ Patients as subjects

☐ Filming, photographing, video- or voice recording of subjects
☐ Data banks, data archives, and/or medical records
☐ Charges incurred by third party carriers
☐ Approved drugs for "Non-FDA" approved conditions
☐Subjects in Armed Services (Active Duty)
☐ Prisoners, parolees, or incarcerated subjects

☐ Pregnant women, human fetuses, and neonates

☐ Sensitive Topics

☐ Non-English speaking subjects

☐ Elderly Subject (over 65)

The principal investigator assures the Committee that all procedures performed under the project will be conducted by individuals legally and responsibly entitled to do so and that any deviation from the project (e.g., change in principal investigatorship, subject recruitment procedures, drug dosage, research methodology, etc.) will be submitted to the review committee for approval **prior** to its implementation.

What do you plan to do with the results? Please provide a brief summary statement below:

I plan to use this research as a stepping stone for future research completed by myself or others who have interest in the topic. Future research would include implementing an intervention to show the direct relationship between leg stability and ballet training. Being that this has not been studied so specifically, the data and results could lead to more influential findings that may impact how dance is taught and studied.

Are you applying to a federal, state, foundation or any non-LMU organization for funding? If so, please list the source:

No

NOTE: Applications and any additional material requested by the IRB will not be processed unless **signed personally** by the principal investigator.

		Haley Loeffler
Date	Signature of Principal Investigator (Required)	Name (printed)
		Mavis Rode
Date	Signature of Faculty Sponsor (Required)	Name (printed)
		Damon Rago
Date	Signature of Department Chair (Required)	Name (printed)
Date	IRB Approval (Signature)	Name (printed)

IRB Approval Number

Please deliver to Julie Paterson, Sr. IRB Coordinator, University Hall, Suite 1718 or jpaterso@lmu.edu.

LOYOLA MARYMOUNT UNIVERSITY

IRB Application Questionnaire

All materials must be typed.

1. RESEARCH BACKGROUND

Please describe the purpose of your research. Provide relevant background information and briefly state your research question(s). You may provide relevant citations as necessary. (300 Word Max.)

The purpose of this research is to determine if there is a relationship between ballet training and stability of the lower extremities in comparison to the general population. After discussing with my dance colleagues, the majority found that over the years, they have determined one leg to be more stable as the supporting leg over the other. They claimed that one leg is more stable when turning and another is more stable in a stationary balance. I have also noticed these trends in my own practice in the studio. In ballet, it is customary to begin each combination with the left leg as the supporting leg and the right as the accessory leg. It has been suggested that over years of this training, the dancer's body might accommodate to such behavior and may favor one side over another. It raises the question if this aspect of ballet training causes an imbalance of stability. Before looking at ballet training specifically, leg dominance must be observed and recorded in comparison to the general, non-dancer population. The above statements lead to the question of whether always beginning with the left hand on the barre and the left leg as the supporting leg, will create an imbalance in left and right lower extremity stability. In order to assess the aforementioned question in future studies, this preliminary observational study on leg dominance and stability must be done.

2. SUBJECT RECRUITMENT

How will subjects be selected? What is the sex and age range of the subjects? Approximately how many subjects will be studied?

How will subjects be contacted? Who will make initial contact with subjects? Specifically, what will subjects be told in initial contact?

If subjects will be screened, describe criteria and procedures.

Subjects will be selected by asking for volunteers who meet the criteria explained in this section. Participants will be only females between the age range of 18-26 years. A minimum of 30 subjects total will be studied. Subjects will be contacted through email outreach as well as face-to-face interaction. Haley Loeffler, the primary investigator, or Christina Reburn, the Research Assistant, will make the initial contact with subjects. Subjects will either be in the dancer or non-dancer group. Participants of the dancer group will be members of the LMU Dance Department, should be enrolled in at least one ballet class for the semester, and have a minimum of 8 years of dance training. Participants of the non-dancer group will be students of the LMU community, non-specific to any particular academic program, that are recognized as

healthy, normally active individuals. These participants should be excluded if they have taken dance class in the last 10 years. Other exclusions criteria include if a participant is a collegiate athlete, has a current injury or a previous injury that is still bothersome or limiting, or has a history of concussions.

3. PROCEDURES

Summarize fully all procedures to be conducted with human subjects.

The procedures will be conducted as follows:

a) Obtain a group of a minimum of 30 total participants by recruiting volunteers that meet the criteria of either the dancer or non-dancer groups. Recruiting techniques include word-of-mouth and email communication.
b) Plan a testing schedule with a faculty member of the Health and Human Sciences Department to use the NeuroCom equipment and lab in which it is held. Once the schedule is determined, ask participants to sign-up for a 20-minute slot using setmore.com or Google Sheets.
c) Each participant will attend one testing session of approximately 20 minutes. This session will consist of:
    i) Educating the participant of the purpose and procedure of the study
    ii) Filling out the Initial Research Participation Questionnaire
    iii) Testing for leg dominance by using the ball-kick, step-up, and balance recovery tests
    iv) Using the NeuroCom equipment by going through the following tests:
        1) Rhythmic Weight Shift*
            (a) Participants will be asked to rhythmically move their center of gravity from left to right and forward to backward between two targets at three distinct speeds.
        2) Unilateral Stance*
            (a) Participants will be asked to stand on either the right or left foot with eyes open and with eyes closed.
        3) Squat*
            (a) Participants will be asked to maintain equal weight on each leg while standing erect and then squatting in three positions of knee flexion: 30°, 60°, and 90°.
        4) Limits of Stability*
            (a) Participants will be asked to intentionally displace their center of gravity in the four cardinal directions and the four diagonal directions, and maintain stability at those positions.
d) Once all testing sessions have been completed, data will be reviewed for a complete analysis of the information acquired; this includes statistical and qualitative analyses.

* Referenced the NeuroCom Testing Protocol Manual

4. RISKS / BENEFITS

What are the potential benefits to subjects and/or to others?

What are the reasonably foreseeable risks to the subjects? (Risks may include discomfort, embarrassment, nervousness, invasion of privacy, etc.) If there are potential risks to subjects, how will they be minimized in advance? How will problems be handled if they occur?

This study has minimal risk for the participants. Some potential risks include slipping on the force plate, falling while trying to balance on the force plate, and embarrassment. To avoid this, participants will be asked to be barefoot to avoid slipping or falling. If an incident does occur, the primary investigator or research assistant will ask the participant to be evaluated by the Student Health Center, if necessary.

The benefits, however, for this study include understanding the stability differences in each of the participant's legs and knowing if the reason for that difference is due to leg dominance or ballet training for the dancer subgroup. For the non-dancer subgroup, the benefit of participating in the study is that they will also understand the comparison of the stability in both of their legs, which they can use as a mechanism for understanding their bodies. Both groups could use this information, if an imbalance is found, to implement changes in their physical activity to decrease this difference.

5. CONFIDENTIALITY

Will subjects be identifiable by name or other means? If subjects will be identifiable, explain the procedures that will be used for collecting, processing, and storing data. Who will have access to data? What will be done with the data when the study is completed? If you are collecting visual images of your subjects please justify this.

Participants will have an ID number to provide a means of confidentiality of results and personal information. Both the investigator, Haley Loeffler, and the Research Assistant, Christina Reburn, will have access to participant data. Participant data will be stored on a private flash drive solely for this project, as well as on the NeuroCom machine itself, as it is DICOM compatible for storing medical records. The NeuroCom and the flash drives are secure mediums of holding participant information and research data.

Seven years following the completion of the study in May 2018, the data will be deleted. This data may be used in conjunction with other data to formulate another study to complement this pilot study in the hopes of answering the research question.

6. INFORMED CONSENT

Attach an informed consent form or a written request for waiver of an informed consent form. Include waiver of written consent if appropriate. If your research is being conducted in another language, please include copies of the translated "Informed Consent" or "Waiver of Written Consent" forms.

See attached.

7. STUDENT RESEARCH

When a student acts as principal investigator, a faculty sponsor signature is required on the application form.

Faculty sponsor is listed on cover sheet.

8. RENEWAL APPLICATIONS

When the submission is a Renewal Application, include a summary of the research activities during the previous granting period specifically addressing: number of subjects studied and any adverse reactions encountered, benefits which have been derived, any difficulty in obtaining subjects or in obtaining informed consent, and approximate number of subjects required to complete the study.

N/A

9. PAYMENTS

If subjects are to be paid in cash, services, or benefits, include the specific amount, degree, and basis of remuneration.

N/A

10. PSYCHOLOGY SUBJECT POOL

When students from the Psychology Subject Pool (PSP) are to be involved as subjects, permission must be obtained from the PSP prior to running subjects.

Forms are available from the Psychology Office in 4700 University Hall. It is not necessary to inform the IRB of approval from the PSP, however the PSP requires IRB approval prior to permission for using the pool being granted.

N/A

11. QUALIFICATIONS AND TRAINING

Describe the qualifications of, or method of training and supervision afforded student experimenters. This includes past experience, type and frequency of student/sponsor interactions during the experiment, and Human Subjects Protections Training.

The primary investigator is an undergraduate health sciences student, investing in pre-physical therapy courses and working in the science labs provided at Loyola Marymount University. She has been trained by Dr. Sarah Strand on the NeuroCom equipment. The investigator is in direct contact with

Mavis Rode and Teresa Heiland, both advisors on the research study. The investigator has completed the Humans Subjects Protection Training in January 2017.

12. RANDOMIZATION

Describe criteria for assigning subjects to sub-groups such as "control" and "experimental."

The subgroups used in this study are titled "dancers" and "non-dancers". The non-dancer group is the control group for this study. A minimum of 15 participants will be in each group for a total of 30 participants in the study. The subgroups listed above will be compared using measured baseline data. Inclusion criteria for the "dancer" group are that the participants be enrolled in at least one ballet class for the spring semester and have been dancing for a minimum of 8 years. Inclusion criteria for the non-dancer group is that they must be an LMU student. Participants will not be included in this group if they have taken any dance class in the last 10 years.

13. USE OF DECEPTION

If the project involves deception, describe the debriefing procedures that will be used.

Include, verbatim, the following statement in the consent form: "Some of the information with which I will be provided may be ambiguous or inaccurate. The investigator will, however, inform me of any inaccuracies following my participation in this study.

N/A

14. QUESTIONNAIRES AND SURVEYS

Include copies of questionnaires or survey instruments with the application (draft form is acceptable).

If not yet developed, please so indicate and provide the Committee with an outline of the general topics that will be covered. Also, when the questionnaire or interview schedule has been compiled, it must be submitted to the Committee for separate review and approval. These instruments must be submitted for approval prior to their use.

Consider your population. If they are foreign speakers, please include copies in the foreign language.

See attached.

15. PHYSICIAN INTERACTIONS

To ensure that all patients receive coordinated care, the principal investigator is obligated to inform the primary physician (when not the principal investigator) of all studies on his/her patients.

N/A

16. SUBJECT SAFETY

Describe provisions, if appropriate, to monitor the research data collected, to ensure continued safety to subjects.

The data collected in this study will maintain privacy and safety by being secured in a thumb drive, allowing access to only the primary investigator and research assistant. Participants' names will be coded and kept separately so that no one will see names immediately next to data or personal information.

17. REDUNDANCY

To minimize risks to subjects, whenever appropriate, use procedures already being performed on the subjects for diagnostic or treatment purposes. Describe provisions.

N/A

18. COUNSELING

In projects dealing with sensitive topics (e.g., depression, abortion, intimate relationships, etc.) appropriate follow-up counseling services must be made available to which subjects might be referred.

The IRB should be notified of these services and how they will be made available to subjects.

N/A

19. SAFEGUARDING IDENTITY

When a research project involves the study of behaviors that are considered criminal or socially deviant (i.e., alcohol or drug use) special care should be taken to protect the identities of participating subjects.

In certain instances, principal investigators may apply for "Confidentiality Certificates" from the Department of Health and Human Services or for "Grants of Confidentiality" from the Department of Justice.

N/A

20. ADVERTISEMENTS

If advertisements for subjects are to be used, attach a copy and identify the medium of display.

Advertising will primarily be made through oral communication and email. The information sent in the email will include the Informed Consent Form, Experimental Subjects Bill of Rights, a description of the reason for conducting the study, a detailed explanation of the procedures, and inclusion and exclusion criteria.

21. FOREIGN RESEARCH

When research takes place in a foreign culture, the investigator must consider the ethical principles of that culture in addition to the principles listed above.

N/A

22. EXEMPTION CATEGORIES (45 CFR 46.101(b) 1-6)

If you believe your study falls into any of the Exemption Categories listed below, please explain which category(ies) you believe it falls into and why.

N/A

1) Research conducted in established or commonly accepted educational settings, involving normal educational practices, such as (i) research on regular and special instructional strategies, or (ii) research on the effectiveness of or the comparison among instructional techniques, curricula, or classroom management methods.

2) Research involving the use of educational tests (cognitive, diagnostic, aptitude, achievement), if information taken from these sources is recorded in such a manner that subjects cannot be identified, directly or through identifiers linked to the subjects.

3) Research involving survey or interview procedures, except where all of the following conditions exist: (i) responses are recorded in such a manner that the human subjects can be identified, directly or through identifiers linked to the subjects, (ii) the subject's responses, if they became known outside the research, could reasonably place the subject at risk of criminal or civil liability, or be damaging to the subject's financial standing, employability, or reputation, and (iii) the research deals with sensitive aspects of the subject's own behavior, such as illegal conduct, drug use, sexual behavior, or use of alcohol.

All research involving survey or interview procedures is exempt, without exception, when the respondents are elected or appointed public officials, or candidates for public office.

4) Research involving the observation (including observation by participants) of public behavior, except where all of the following conditions exist: (i) observations are recorded in such a manner that the human subjects can be identified, directly or through the identifiers linked to the subjects, (ii) the observations recorded about the individual, if they became known outside the research, could reasonably place the subject at risk of criminal or civil liability, or be damaging to the subject's financial standing, employability, or reputation, and (iii) the research deals with sensitive aspects of the subject's own behavior such as illegal conduct, drug use, sexual behavior, or use of alcohol.

5) Research involving the collection or study of existing data, documents, records, pathological specimens, or diagnostic specimens, if these sources are publicly available or if the information is recorded by the investigator in such a manner that subjects cannot be identified, directly or through identifiers linked to the subjects.

6) Unless specifically required by statute (and except to the extent specified in paragraph (1)), research and demonstration projects which are conducted by or subject to the approval of the Department of Health and Human Services, and which are designed to study, evaluate, or otherwise examine: (i) programs under the Social Security Act or other public benefit or service programs, (ii) procedures for obtaining benefits or services under those programs, (iii) possible changes in or alternatives to those programs or procedures, or (iv) possible changes in methods or levels of payment for benefits or services under those programs.

Please deliver to: Julie Paterson, IRB Coordinator, University Hall, Suite 1718 or jpaterso@lmu.edu.

LOYOLA MARYMOUNT UNIVERSITY

Informed Consent Form

Date of Preparation _____

Loyola Marymount University

(Title in Lay Language)

1) I hereby authorize Haley Loeffler to include me in the following research study: Exploring Leg Stability among Dancers.

2) I have been asked to participate on a research project which is designed to test the bilateral differences in stability and balance measured by the NeuroCom and which will last for approximately one semester.

3) It has been explained to me that the reason for my inclusion in this project is that I am a student of Loyola Marymount University, either a dancer or non-dancer, female, and between the age of 18-26. If I am categorized as a dancer, I am enrolled in at least one ballet course this semester. If I am categorized as a non-dancer, I have not taken a dance class in the last 10 or more years.

4) I understand that if I am a subject, I will participate in one testing period using the NeuroCom, lasting about 30 minutes long. I will answer as best I can all questionnaires that are given to me by the primary investigator.

   The investigator(s) will provide detailed explanations for the procedures of each testing period, which will be scheduled by the investigator. The investigator will analyze the data and later share with me the results.

   These procedures have been explained to me by Haley Loeffler, Bachelor of Science and Bachelor of Arts candidate.

6) I understand that the study described above may involve the following risks and/or discomforts: balancing on an uneven force plate, balancing on different surfaces with my eyes closed, and the potential for falling or slipping.

7) I also understand that the possible benefits of the study are understanding the stability differences in each of my legs and knowing if the reason for that difference is due to leg dominance or my ballet training.

8)I understand that Mavis Rode who can be reached at mrode@lmu.edu or (310)258-5597 will answer any questions I may have at any time concerning details of the procedures performed as part of this study.

9) If the study design or the use of the information is to be changed, I will be so informed and my consent reobtained.

10)I understand that I have the right to refuse to participate in, or to withdraw from this research at any time without prejudice to (e.g., my future medical care at LMU.)

11)I understand that circumstances may arise which might cause the investigator to terminate my participation before the completion of the study.

12)I understand that no information that identifies me will be released without my separate consent except as specifically required by law.

13)I understand that I have the right to refuse to answer any question that I may not wish to answer.

14)I have been informed that my insurance carrier and I are financially responsible for any and all medical or other expenses related to any injury caused by my participation in this study.

15)I understand that in the event of research related injury, compensation and medical treatment are not provided by Loyola Marymount University.

16)I understand that if I have any further questions, comments, or concerns about the study or the informed consent process, I may contact David Moffet, Ph.D. Chair, Institutional Review Board, 1 LMU Drive, Suite 3000, Loyola Marymount University, Los Angeles CA 90045-2659 at david.moffet@lmu.edu.

17)In signing this consent form, I acknowledge receipt of a copy of the form, and a copy of the "Subject's Bill of Rights".

Subject's Signature _____ Date _____

Subject's Name (please print) _____ Date _____

Witness _____ Date _____

LOYOLA MARYMOUNT UNIVERSITY

Experimental Subjects Bill of Rights

Pursuant to California Health and Safety Code §24172, I understand that I have the following rights as a participant in a research study:

1. I will be informed of the nature and purpose of the experiment.

2. I will be given an explanation of the procedures to be followed in the medical experiment, and any drug or device to be utilized.

3. I will be given a description of any attendant discomforts and risks to be reasonably expected from the study.

4. I will be given an explanation of any benefits to be expected from the study, if applicable.

5. I will be given a disclosure of any appropriate alternative procedures, drugs or devices that might be advantageous and their relative risks and benefits.

6. I will be informed of the avenues of medical treatment, if any, available after the study is completed if complications should arise.

7. I will be given an opportunity to ask any questions concerning the study or the procedures involved.

8. I will be instructed that consent to participate in the research study may be withdrawn at any time and that I may discontinue participation in the study without prejudice to me.

9. I will be given a copy of the signed and dated written consent form.

10. I will be given the opportunity to decide to consent or not to consent to the study without the intervention of any element of force, fraud, deceit, duress, coercion, or undue influence on my decision.

Subject: Sign Up for Haley Loeffler's Dance Research Thesis!!!
Date: Wednesday, February 7, 2018 at 12:05:35 PM Pacific Standard Time
From: Dance

Dear Dancer Community,

My name is Haley Loeffler, a senior Health & Human Sciences and Dance Double Major.
I am conducting a senior thesis research project entitled: **[3]Exploring Leg Stability among Dancers[2]**.
I[1]m looking for both dancers and non-dancers to participate in this study.

The purpose of this research is to determine if there is a relationship between ballet training and the stability of the lower body in comparison to the general population. This will be tested by the use of the NeuroCom Balance Assessment machine which will test your stability in a variety of standing positions. As a participant, you will have to commit to **one 30-minute** testing session between February 9th and March 23rd in **LSB 154**.

To be a participant in this study, you must meet the following:
Current student of Loyola Marymount University

Female
Between
the ages of 18-26
Enrolled
in at least 1 ballet class for the Spring 2018 semester*
Minimum
of 8 years of dance training*
*for the dancer group
only

Your participation will be excluded from this study if you:

Have
a current injury or previous injury that is still limiting (esp. foot, ankle, knee, hip, lower back, thigh, calf, etc.)
Have
a history of concussions
Have
a scoliosis
Have
been informed of a significant difference in leg length
Have taken
a dance class in the last 10 years (not including Zumba, or other dance fitness classes)**
Are a collegiate athlete
**for the non-dancer
group only

The benefits for participating in this study for the dancer subgroup include understanding the stability differences in each of your legs and knowing if the reason for that difference is due to leg dominance or ballet training. Benefits for the non-dancer subgroup include understanding the comparison of the stability in both of your legs, which you can use as a mechanism for understanding your body.

Attached, please find the Informed Consent Form and the Subject Bill of Rights. Once you have committed to the study and scheduled your time slot to come in for testing, please bring a signed copy of the Informed Consent Form with you to your testing session.

Sign up for this session using the following link:
https://exploringlegstabilityamongdancers.setmore.com/resourcebookingpage/r6863252c9a67016e18d5b725db8c1807805f8643

If you have further questions, contact Haley Loeffler at hloeffle@lion.lmu.edu.

Thank you for your consideration,

Haley Loeffler

ID # _____

Date: _____

Initial Research Screening Questionnaire

1) Age: _____

2) _____Dancer _____Non-Dancer

   a) If dancer:

      i) How long have you been training in dance? _____

      ii) Perceived level of ballet: _____Advanced _____Intermediate _____Beginner

      iii) Standing leg pref. in a turn: _____L _____R _____No preference

      iv) Stationary balancing leg: _____L _____R _____No preference

3) Leg dominance:

   a) Ball kick: _____L _____R

   b) Step-up test: _____L _____R Determined leg dominance:_____L_____R

   c) Balance recovery: _____L _____R

4) Physical Activity

   a) Type: _____

      i) Any single leg balance exercises? _____Yes _____No

   b) How often? _____

5) Have you ever had an Injury? _____Yes _____No

   a) If yes:

      i) Where was the injury located? _____

      _____

      ii) Have you been treated for this injury? _____Yes _____No

      iii) Does this injury still bother you?_____

6) History of concussion? _____Yes _____No

7) Difference in leg length? _____Yes _____No

8) Scoliosis? _____Yes _____No

LMU|LA
Frank R. Seaver College
of Science and Engineering

Health and Human Sciences

Life Sciences Building
1 LMU Drive, MS8888
Los Angeles, CA 90045-2659

Tel 310.338.7585
Fax 310.338.3417
www.lmu.edu

December 6, 2017

Dr. Moffett and the LMU Institutional Review Board,

This letter serves as my permission for Ms. Haley Loeffler to us Life Sciences Building room 154 (Sports Medicine Lab), and the Neurocom Balance Assessment machine in the lab.

Best,

Sarah Strand, PhD, ATC
Associate Professor
Department of Health and Human Sciences
310-568-6646
Sarah.Strand@lmu.edu

Certificate of Completion

The National Institutes of Health (NIH) Office of Extramural Research certifies that **Haley Loeffler** successfully completed the NIH Web-based training course "Protecting Human Research Participants".

Date of completion: 01/24/2017.

Certification Number: 2291289.

Certificate of Completion

The National Institutes of Health (NIH) Office of Extramural Research certifies that **Christina Reburn** successfully completed the NIH Web-based training course "Protecting Human Research Participants".

Date of completion: 12/06/2017.

Certification Number: 2577129.

Certificate of Completion

The National Institutes of Health (NIH) Office of Extramural Research certifies that **Mavis Rode** successfully completed the NIH Web-based training course "Protecting Human Research Participants".

Date of completion: 12/06/2017.

Certification Number: 2577120.

Part 3: Appendix B

Commentary & Reflection

Commentary & Reflection

Section 1: Genesis of Project

I wanted to do a project of this nature to combine my dance studies with those that I've learned from Health & Human Sciences as well. A year ago, I was a research assistant for Hawley Almstedt on one of her projects that spanned over one-hundred participants. She instilled in me that research can research is a great tool because you can have a question and then have an answer. Now it's not as simple as that seems, but when the time came to needing a topic to research I immediately thought about ballet technique. I had always questioned why in every ballet class it is customary to start with the left hand on the barre. My thoughts then led me to thinking if my left leg was going to be more stable because I used it first and I used it more often as my standing leg than on the right leg. I originally wanted to tackle an interventional study and have my participants change which hand they started with on the barre. While a great question, I realized, with help from Mavis, that this couldn't yet be determined unless it was proven to be independent of leg dominance. So, from there I created this pilot study.

I had personally never created a research project before so this whole process was going to be very new for me. I first had to do some initial research and narrow down the specific question I was going to look at. Then, I had to submit an IRB proposal to the university which I had never done before, but had guidance with.

Since starting and now finishing the project, I have thought about leg stability at the ballet barre a lot! Almost every class. This study didn't really affect my artistic ability, but it did give me information on the physicality of my dancing, which I think is just as valuable.

Section 2: Step-by-Step Process

Find initial research
Develop a question
IRB proposal (submitted 12/1/17)
Recruit participants (began 1/8/18)
Begin Data Collection (2/9/18)
End Data Collection (3/16/18)
Data Analysis
Write formal paper
Write commentary & reflection
Assemble thesis

Overall, I think the process went very smoothly. I felt prepared and excited in what I was doing which made all the difference in the long run. The biggest challenge was getting over the hurdle that is SPSS, a statistical analysis software that is commonly used in research studies. I didn't have a lot of help so my research assistant, Christina Reburn, and I tried to figure it out on our own. If I had the knowledge and background in SPSS, this study would have turned out to be much more statistically involved. It was honestly a really enjoyable experience and I would do it again if I had to.

Section 3: Final Results and Thoughts

I am very happy with the way my project turned out. I learned a lot about myself and how I work, but I also just had a lot of fun. Answering my own question is so much different than answering someone else's. I actually care about the results and am intrigued into how I could possibly combine my two areas of study into something cohesive and something that mattered. The statistical analysis is something that will need to be in the works and adjusted to be more comprehensive if I were to publish this to an academic journal. This project was meant to be a rough draft for a paper I could take and use for the rest of my life. I'm very glad I did this and look forward to working out the kinks over time with some extra mentorship.

Section 4: What's Next?

I see myself taking this project to conferences, doing poster presentations, and just talking about it because it's cool. I feel that once I solidify this information, I can continue on to the bigger question I have about dance training and starting with the left hand on the barre.

Within the next 10-15 years, I would like to become a Doctor of Physical Therapy for dancers. I think this study is the stepping stone to becoming a future researcher and physician. This has been my dream, as well as becoming a professional dancer, for the last 12 years of my life. I cannot wait to dive into both careers and see where they take me. I'm so thankful for LMU and where it has got me. I so excited to see what world lies out there.

Part 4: Appendix C

Supplementary Documents

Data Collection Procedure

Step 1: Turn on the NeuroCom, then Computer. Prepare the necessary start-up procedures for NeuroCom.
- Make sure green cord is screwed in
- Make sure USB in plugged in

Step 2: Collect signed Informed Consent Form & go over the Subject Bill of Rights.
- Give participant a copy if they do not bring one in.
- Clarify details and ask questions

Step 3: Assign participant an ID, but keep this confidential to only you.

Step 4: Fill out the Initial Research Screening Questionnaire as the participant answers the corresponding questions.
- **2a**: Ensure that the dancer is enrolled in 1 ballet class this semester
- Leg dominance
    - Drop the soccer ball and have them kick it
    - Step up onto a raised surface
    - Slightly push them forward
- If a participant answers yes to :
    - **5iii** or **6**
        - Still perform the NeuroCom test; Need to ask for informal consent to use their data at a later date; we may need to exclude them.
    - **7** or **8**
        - "Has a physician ever told you about a difference in leg length/scoliosis?"
        - If no, but maybe?:
            - Tell them to see Mavis to assess them. Then they can come back for another appt. if negative.

Step 5: Rhythmic Weight Shift

Step 6: Unilateral Stance
- 10 seconds between L and R

Step 7: Weight Bearing Squat

Step 8: Save and upload Analysis sheets to Google Drive

Step 9: Wipe down force plate.

Step 10: Turn off the computer, then NeuroCom.

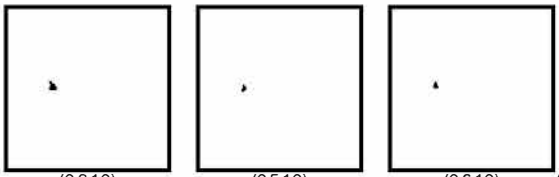
Name: C204, C204
Date of Birth: 7/2/1997
Referral Source: Not Specified
Position: Not Specified
Injury History:

Height: 5'7"

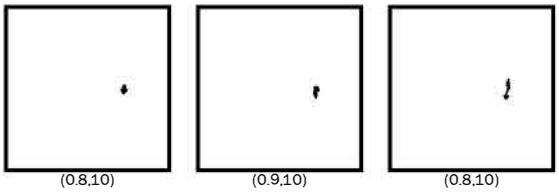
ID: 57658a40-a5e8-4eb8-9d13-bd5357d5b459
File: FD57658a40-a5e8-4eb8-9d13-bd5357d5b459.XDRX2
Operator: Not Specified
Date: 2/14/2018
Time: 19:44:47

Unilateral Stance

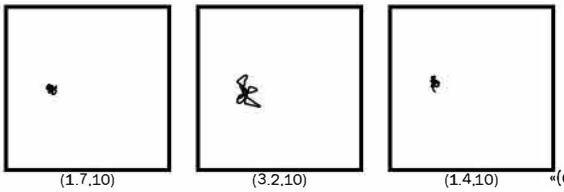
1. LEFT-Eyes Open(L-EO)



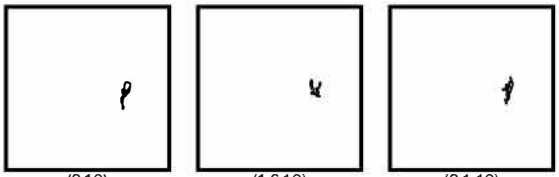
3. RIGHT-Eyes Open(R-EO)



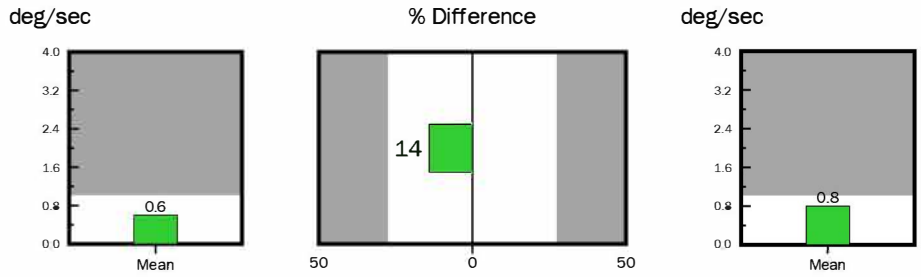
2. LEFT-Eyes Closed(L-EC)



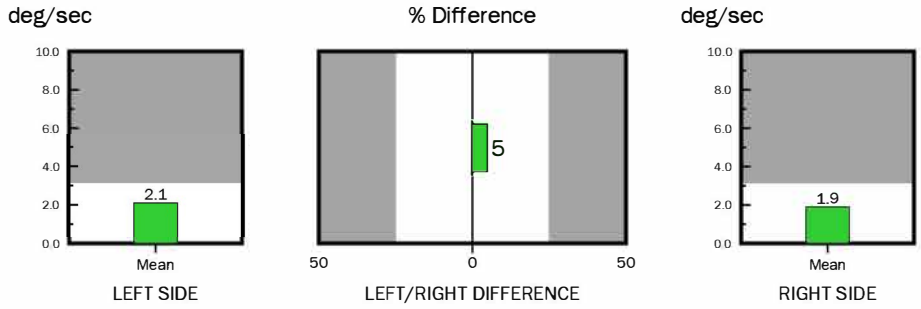
4. RIGHT-Eyes Closed(R-EC)



Mean COG Sway Velocity(Eyes Open)



Mean COG Sway Velocity(Eyes Closed)



Data Range Note: NeuroCom Data Range: 20 - 39

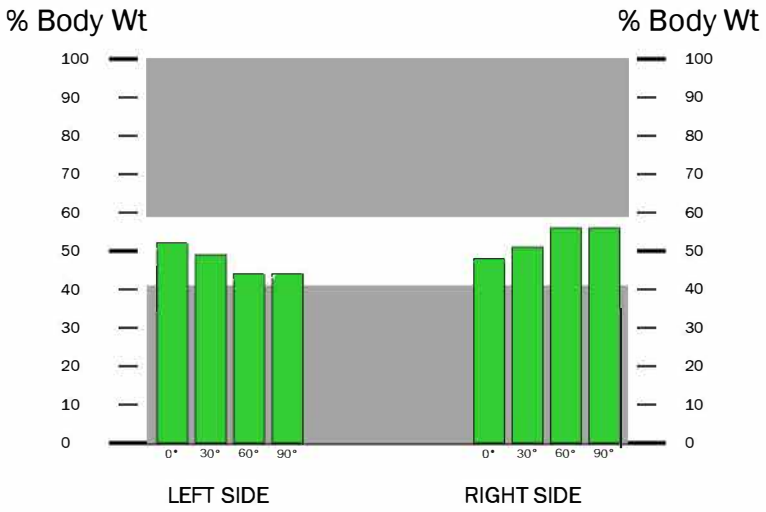
Post Test Comment:

Name: C204, C204
Date of Birth: 7/2/1997
Referral Source: Not Specified
Position: Not Specified
Injury History:

Height: 5'7"

ID: 57658a40-a5e8-4eb8-9d13-bd5357d5b459
File: FD57658a40-a5e8-4eb8-9d13-bd5357d5b459.XDRX2
Operator: Not Specified
Date: 2/14/2018
Time: 19:49:33

Weight Bearing/Squat



Percentage Weight Bearing

Angle	Left	Right
0°	52	48
30°	49	51
60°	44	56
90°	44	56

Data Range Note: NeuroCom Data Range: 20 - 39

Post Test Comment:

Name: C204, C204
Date of Birth: 7/2/1997
Referral Source: Not Specified
Position: Not Specified
Injury History:

Height: 5'7"

ID: 57658a40-a5e8-4eb8-9d13-bd5357d5b459
File: FD57658a40-a5e8-4eb8-9d13-bd5357d5b459.XDRX2
Operator: Not Specified

Weight Bearing/Squat

Test Date: 2/14/2018
Test Time: 19:49:33

SIDE	0°	30°	60°	90°
Left(% Body Wt)	52	49	44	44
Right(% Body Wt)	48	51	56	56